ORBITAL ANOMALIES IN GODDARD SPACECRAFT

FOR

CY 1988

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Summary

This report presents a summary of the in-orbit reliability performance of spacecraft built under the management of the Goddard Space Flight Center that were active during calendar year 1988. It is one of a series of such reports that collectively form a continuous published record of this performance. The major feature of these reports is a log of all anomalies occurring during the report period which provides a description of the anomaly and its time of occurrence. Each anomaly is classified according to criticality, type, subsystem, and other relevant criteria. Although some statistical analysis and comparisons are given, the purpose of the report is primarily documentary, with more extensive statistical treatment to be presented elsewhere.

Introduction

Since the earliest days of the Center, attempts have been made to record the performance of Goddard-managed spacecraft. Although statistical summaries exist, until the last 15 years or so the actual raw data was considered sensitive and was not published. This is unfortunate, since over the years it has been observed that the potential uses for this data are open-ended and cannot be predicted in advance. Hence, any predigested data is likely not to be what is needed in many instances.

The first report to contain specific anomaly data was the contractor report Analysis of Spacecraft On-Orbit Anomalies and Lifetimes, PRC R-3579, dated 10 February 1983, which covers roughly the period from'1978 to mid-1982, and includes JPL as well as GSFC spacecraft. This was followed by Orbital Anomalies in Goddard Spacecraft 1982-1983, Orbital Anomalies in Goddard Spacecraft 1984, ...1985, ...1986, ...1987 published by the Office of Flight Assurance. The current report updates the record through 1988.

Spacecraft Activity Schedule

At the beginning of this reporting period, on January 1 1988, there were a total of 19 GSFC spacecraft in full or partial service. This number includes 10 meteorological spacecraft operated by NOAA consisting of two of the TIROS/NOAA series and six of the GOES series; Landsat-4, and Landsat-5.

There were two new spacecraft launched during the year and one old spacecraft was put on standby. In September both the NOAA-11 (H) spacecraft and the TDRS-3 (C) spacecraft were successfully launched. (NOAA-11 launched on an Atlas and the TDRS-3 on STS-26.) In November the NOAA-9 spacecraft was placed in standby mode in orbit after almost five years in service. It appeared to be in fair condition when put in standby although the MSU and ERBE Scanner Instruments had failed and the AVHRR and Power Subsystem were degraded. The complete list of satellites active during all or part of 1988 is as follows:

NASA		NOAA
AMPTE/CCE		NOAA-9
DE-1	0	NOAA-10
ERBS	N	GOES-2
IMP-8	G	GOES-3
ICE (ISEE-3)	0	GOES-4
IUE	I	GOES-5
NIMBUS-7	N	GOES-6
SMM	G	GOES-7
TDRS-1		Landsat-4
		Landsat-5
TDRS-3	NEW	NOAA-11

Details are shown in the Spacecraft Lifetime Data in Appendix A, which includes virtually all GSFC launches since 1960, excluding minor GAS (Get Away Special) experiments and a number of international missions Goddard participated in but is not considered to have had responsibility.

Overall there were 25 anomalies, distributed over 10 different spacecraft, during the year. This compares with 43 anomalies distributed over 11 spacecraft in the previous year (1987).

In the following sections, each mission and its overall performance is discussed in more detail. A complete log of anomalies appears at the end of the report.

Data Sources

The data reported herein are taken primarily from three sources. For NASA spacecraft, the main source is the Spacecraft Orbital Anomaly Reports (SOAR). For TIROS/NOAA spacecraft the TIROS Orbital Anomaly Reports (TOAR) are used, and the GOES Anomaly Reports (GAR) cover the GOES series. These data bases are maintained by the Assurance Requirements office, in the case of SOAR, and the METSAT Office in the case of TOAR and GAR. The information contained in these reports originates in the corresponding spacecraft operations control centers. Supplementary information is obtained through miscellaneous written reports, attendance of the regular meetings of the Orbiting Satellites Project, and other verbal contacts. Additional backup information on many of these anomalies is available through this office, and are subject to revision. This applies particularly to "open" anomalies.

Spacecraft Performance Summary

The following provides a summary of the condition and performance of the active spacecraft covered by this report:

AMPTE/CCE (Active Magnetospheric Particle Tracer Explorers/Charge Composition Explorer)

This spacecraft continued to obtain scientific data through this year and in August it celebrated its 4th anniversary. At the end of January Coulometer 2 on Battery 1 and 2 failed. Another coulometer had failed last year. Coulometer 1 on Battery 2 is still functioning but these coulometers are not required for normal operations. The spacecraft successfully endured a long eclipse in February; however, in April, Command Processor (System) No. 1 failed and a switch to Command Processor No. 2 was made by control center command. The cause of this failure is thought to be failure of CMOS Harris PROM's as a result of cumulative radiation damage after over 3.5 years in orbit.

DE-1 (Dynamic Ex-olorer)

This spacecraft operated throughout the year with out any anomalies, achieving 7 years in orbit in August. It still endures low power periods and curtailment of operations to prevent over-temperature on the tape recorder. It continued to perform worthwhile science and supported various special programs.

ERBS (Earth Radiation Budget Satellite)

This spacecraft fulfilled all its scientific objectives for this year and, in general, performed very well. The number of command memory bit changes (bit-flips) this year was fairly low (about 20) and none caused any operational problems.

On July 12 the Y-gyro in IRU-2 (Inertial Reference Unit) stopped due to bearing wear out. Such a failure had been expected to occur since the failure of the X-gyro in IRU-1 in August 1986. Since a "No X-gyro" procedure had already been developed by July of last year, the IRU-1 system was powered up, IRU-2 was turned off, and a yaw turn maneuver was performed in late July using the new procedure. It worked successfully and has been used since for the periodically-required yaw turns. Since reactivation of IRU-1 in July, the noise levels of the Y and Z gyros has been increasing.

Eventually one (or both) of these gyros will fail; at that time a "gyroless" yaw turn procedure, already developed, will be implemented.

In October the ERBE (Earth Radiation Budget Experiment) Scanner Instrument's digital to analog converter reached the “yellow" low limit. This has not caused any problem so far but eventually may reach the lower limit of the balance range. This drift is due to detector aging.

GOES (Geostationary Operational Environmental Satellite)

GOES-4: This spacecraft continued to provide ESA (European Space Agency) with DCS (Data Collection System) service at 43 degrees W. longitude until ESA successfully launched Meteosat III in July. After checkout, ESA DCS service was transferred to their new spacecraft. A series of maneuvers in October and November raised GOES-4 approximately 3OOkm above geosynchronous and depleted all remaining fuel. Spacecraft systems were commanded to the deactivated configuration on 22 November ending more than 8 years of spacecraft life of which two years and one month GOES-4 served as the West operational (imaging) satellite.

No anomalies were reported in 1988.

[One SOAR, written on this spacecraft in 1987 was not included in the log (Table) of anomalies in the report, "Orbital Anomalies in Goddard Spacecraft for CY1987". The text of the 1987 report did discuss this anomaly, failure of DCPR (Data Collection Platform Report) transmitter-2. This anomaly is being listed in the anomaly table in this report, enclosed in brackets and marked with an asterisk.]

GOES-5: GOES-5 was operated as the CENTRAL Spacecraft at the beginning of the year at 108 deg. W providing Central WEFAX (weather Facsimile) and backup DCS support. In anticipation of GOES-6 VAS (VISSR Atmosphere Sounder) failure forcing a one-GOES operation, it was decided to repetition GOES-5 to 65 deg W in preparation for taking over East support when GOES-7 became the only imaging spacecraft and repositioned to a central location. The repetition was done slowly between February 9 and March 24. On March 25 GOES-5 started a combined CENTRAL/EAST WEFAX broadcast schedule, relieving GOES-7 of all WEFAX support. In October GOES-5 took over East DCS support and started transponding GOES-7 mode AAA VAS in parallel with GOES-7. (VISSR/VAS is inoperable and SEM (Space Environmental Monitor) is semi-operational due to degraded and failed channels.)

GOES-6: This spacecraft served as the West operational spacecraft during all of this year positioned at 135 deg West Longitude. It provided Mode AAA VAS, WEFAX, DCS and SEM support. One anomaly, opened on March 9, was written this year. The telemetry system has been permanently degraded due to an SEU (Single Event Upset) on this date. Five SEU's preceding this one, between March 4 and 9, were corrected by ground command. (Six SEU's in such a short time is highly unusual for GOES. There have been only 12 such events in the past 5 years spread over all the GOES spacecraft.) The degradation consists of loss of a few Analog and Bilevel channels.

The VAS Instrument operated the entire year on the last good encoder lamp (Primary Scan Drive, Lamp l). At the beginning of the year the lamp was at voltage step 2 but by mid-March it was necessary to increase to step 3 due to too many erroneous scan lines and retrace hangups. On May 31 the VAS Instrument completed 5 years of operation - the longest operational life ever achieved by any GOES imaging instrument. By summer the number of erroneous lines had increased again and turn-on of heaters warmed up the encoder enough to decrease the number of bad lines. The system continued to require nursing throughout the remainder of the year.

NOTE: Prior to publication of this report the last encoder lamp failed on January 21, 1989, permanently ending VAS imaging on this spacecraft.

Scan mirror torque control procedures were utilized throughout the year and continued to effectively manage beginning and end of frame lubricant buildup.

In mid-November, the Primary Power Supply was inadvertently commanded ON by operator error, placing it in parallel with the Redundant Power Supply. This caused an increase in overall VAS temperature, including the encoder, reducing slightly the number of erroneous lines. Both power supplies were left on for the remainder of the year.

(The SEM was operational during the year with the EPS E-1 (Energetic Particle Sensor**)** channel unusable due to radiation damage to the detector.)

[As in the case of GOES-4, above, some SOAR's opened on GOES-6 in CY1987 were not included in the 1987 Anomaly Report and are being included in this 1988 report, and are appropriately marked. There are 3 reports: One, the failure of VAS encoder lamp was discussed in the 1987 Anomaly Report. The second, occurring on 11/l/87, involved a transient event (probably electrostatic discharge) that momentarily shifted the VAS Earth-view window and put X-ray in CAL mode. The third, on December 15, concerned an E-W maneuver that produced only 27% of predicted orbit change. This was corrected by changing data in ground control procedures.]

GOES-7: This spacecraft served as the East Operational Spacecraft during most of this year, positioned at 75 deg West Longitude. It provided Mode AAA VAS, WEFAX, and DCS. After GOES-5 was on station at 65 deg W in March, East WEFAX was transferred to that spacecraft. GOES-7 was allowed to drift slowly westward in anticipation of GOES-6 VAS failure forcing a one-GOES operation but was halted at 80 deg W in December as GOES-6 continued to function. East DCS support was transferred to GOES-5 in October.

In early June the first and only SEU anomaly occurred when the REPLY BUS switched uncommanded from A to B in CTU-1 (Central Telemetry Unit). In mid-September, following a spacecraft eclipse, the ranging station could not lock up on the downlink. Telemetry indicated very low ranging transponder output power which gradually returned to normal a few hours later, when unit temperatures returned to normal. In the future no ranging activity will be scheduled until 3 hours following eclipse.

The VAS performed flawlessly throughout the year. The LED equipped encoder Redundant Scan Drive has now operated 21 months with no evidence of any erroneous scan lines. Scan mirror lubricant buildup caused end-of-frame motor torque to exceed 20 in.-oz. in June. Torque control procedures were put into effect and lubricant buildup has been easily controlled.

(The SEM Instruments are operational except for the HEPAD (High Energy Proton & Alpha Detector) which experienced an anomaly in March 1987.)

[There were also two 1987 anomaly reports written that did not appear in the 1987 Anomaly Report Table of Anomalies. These anomalies, however were discussed in the text portion of the 1987 Report. They are being included in this 1988 report in the Table of Anomalies, appropriately marked.)

ICE (International Cometarv Explorer) (formerly ISEE-3)

This 10-year old spacecraft continued to operate successfully throughout this year without any reported anomalies. It continued to provide some good science in its highly eccentric orbit. (Several instruments are partially degraded and the battery failed in December 1981; spacecraft solar arrays always in full sun so battery not needed.)

IUE (International Ultraviolet Exolorer)

In general this spacecraft, almost 11 years in orbit, continued to produce excellent science throughout the year.
The semiannual shadow seasons still tasks the aging batteries heavily and some special tests for the power engineers were run preceding the shadow season in August. The batteries did perform satisfactorily during this shadow period. Earlier in the year it was noted that Battery No. 1 behaves the worst in these periods. Since the IUE has only two operational gyros

left, work on a "1-gyro system" continued through the year. In addition, work has been ongoing on a "No-gyro system" and a successful test of this system was conducted in late October.

Landsat-4

There were no reported anomalies (no SOAR'S) in 1988. The Multispectral Scanner (MSS) continues to supply data and the Thematic Mapper (TM) continues to produce pictures. This is accomplished by curtailing power usage by other parts of the spacecraft when the TM is operating. This is necessary because of the degradation of the power subsystem.

Landsat-5

Like Landsat-4 there were no anomalies reported on this spacecraft for 1988. Since the Ku-Band system is out of commission, the only way TM data can be transmitted to the ground is via X-Band to a ground station. There are a number of foreign ground stations that are receiving TM imagery. The TM is operating satisfactorily and the MSS continues to operate satisfactorily.

Nimbus-7

In October this spacecraft celebrated 10 years in orbit.

Earlier, on July 6th, the SMMR (Scanning Multi-channel Microwave Radiometer) Instrument was turned off at NASA Headquarters' direction. The SMMR scan mechanism failed, making continued data collection useless.

Instruments which continue to operate are: the SAM II (Stratospheric Aerosol Measurement II), the SBUV/TOMS (Solar Backscatter Ultraviolet/Total Ozone Mapping Spectrometer), and the ERB (Earth Radiation Budget).

The SAM II experiences a shading problem at the South Pole activation from February through September.

The SBUV chopper non-sync monitor indicates continuous non-sync. This does not appear to significantly affect the data, but has a strong impact on the scientific utility of it. The TOMS chopper non-syncs occur over a small percentage of the data. TOMS still provides important Antarctic ozone hole data relating to ozone depletion in the atmosphere, which is a problem that has attracted worldwide attention.

The ERB continues to operate (as it has since June 1980) in the non-scan nadir view and solar data collection.

There were only minor anomalies that occurred during the year. In June, Tape Recorder #3 appeared to have a ten minute record section of very noisy and therefore unusable data. Later, re-recording over this section produced normal data. Also in late July, a transponder and a transmitter off command failed to execute from the on-board Comstor command load. Subsequent executions of this command were normal.

On November 9th three tape recorder **#2** telemetry functions failed at the same time. These tape recorder monitoring telemetry functions had no effect on the recorded data and that tape recorder continues to be used without any problem.

NOAA- 9

At the beginning of the year the spacecraft continued to experience the power subsystem problems that began last year with the loss of solar array shunts and Battery-2 overcharge. In February and March there was considerable automatic array slewing activity and the remaining shunts were being driven hard. Additional shunts may have failed. In August and September there was a gradual worsening of the shunt problem causing many glitches on the 28 volt bus. In March there was some concern over partially frozen hydrazine in the plumbing; there is a danger of the lines rupturing.

In mid-June the HIRS (High Resolution Infrared Radiation Sounder) Instrument experienced an abrupt change in filter wheel motor current with an associated one-time sync loss. The instrument data was not affected.

In late August the AVHRR (Advanced Very High Resolution Radiometer) was re-syncing once per orbit with the MIRP (Manipulated Information Rate Processor), however the data was still usable. By late September the AVHRR was re-syncing up to 4 times per orbit. In late October the re-syncing problem became so severe that the scan motor was commanded into the low power mode.

On the 8th of November NOAA-9 was placed in standby due to the fact that NOAA-11, which had been launched on September 24th, was put in regular service by NOAA as prime afternoon spacecraft. Following this date the NOAA-9 was still providing low rate science data; i.e., 100 percent of the ERBE (Earth Radiation Budget Experiment) and SBUV (Solar Backscatter Ultra-Violet) Energy products. [The SARR (Search and Rescue Repeater), APT (Automatic Picture Transmission), and DCS (Data Collection System) are also operational and can be used if necessary.)

At the time of placement into standby the spacecraft was one month shy of being 4 years in orbit.

NOAA- 1 0

Things were going well in the first months of the year. In late April an anomaly occurred in the AVHRR Instrument. The channel 3 noise level, motor current, and sync delta word all showed an abrupt increase. Lack of lubricant in the motor bearings was thought to be the problem. In mid-May TCE-24 (Temperature Control Electronics) was disabled which raised the temperature of the AVHRR, forcing lubricant into the bearings. This caused the anomalous parameters to return to normal. In August an outgassing test of the AVHRR was performed and this reduced the Channel 3 noise level further. In late November the AVHRR sync delta word suddenly indicated higher jitter. On 12/4 the motor current became erratic for about an hour, there were many dropouts and this portion of the data was unusable. It was noted that the severity of this problem seemed to be temperature dependent. This jitter carried into mid-December but the instrument was still fully operational and no user complaints were received. All other instruments are fully operational.

In mid-May voltage spikes of about -6 volts were seen on the partial shunt voltage bus. This may be indicative of some shunt loss. The array was offset 40 degrees to reduce shunt loading. All through August the shunt problem worsened and the noise level in the partial shunt drive voltage continued to be undesirably high.

On September 9 the SARP (Search And Rescue Prototype) Instrument ceased transmitting. The instrument had failed and it does not have a redundant side. The SARR is fully operational.

In mid-September a minor anomaly occurred in the Telemetry and Data Handling subsystem involving a 25 dB dip in signal strength in the HRPT reception. This has been seen before on previous missions and it does cause some data loss.

As of September 17 NOAA-10 had been in orbit two years.

NOAA-11

On September 24 NOAA-11 was successfully launched and subsystem checkout was started. On November 8, NOAA-11 replaced NOAA-9 as the operational afternoon ascending spacecraft. During this time an anomaly was written on the SARR (Search And Rescue Repeater). The Side A experimental 406.5 MHz receiver channel experienced a 20 dB loss in sensitivity. This is under investigation by the supplier, Canada. The satellite is fully operational.

SMM (Solar Maximum Mission)

This spacecraft continued to provide valuable scientific information about the Sun during this year. In March the SMM observed a period of the highest solar activity seen since launch over 8 years earlier. Again in June it recorded 4 of the

largest solar flares (X-type) ever seen since launch. More than once during the year the SMM has observed new comets passing near and impacting the Sun. In April the spacecraft reached 4 years since the SMRM (repair mission).

There were no anomalies reported on the spacecraft in 1988.

Discussions continued during 1988 concerning the re-entry of SMM sometime in late 1989 or 1990. The project and many scientists were hopeful that NASA Headquarters would decide to arrange for an STS mission to rendezvous with the spacecraft, capture it and re-boost it to a higher orbit.

[Prior to publication of this report it was decided by NASA that SMM would not be re-boosted and would be allowed to reenter and be destroyed. This will probably occur around the end of 1989.]

In the May-June time frame the aging batteries in SMM started to act up somewhat but did not cause any loss of data. In October there were some minor intermittent problems with the crystal drive in the XRP (Soft X-ray Polychromator). It would stick momentarily. The situation was improved somewhat by switching power sources.

In the August-September period the SMM performed some scientific collaborations with a recently launched Russian spacecraft called Phobos.

TDRSS (Tracking and Data Relay Satellite System)

TDRS-1: In April this spacecraft had its 5th anniversary providing user services from orbit. This was joined in orbit on 9/29 when the TDRS-C(-3) spacecraft was, placed in orbit by STS-26, the first STS launch since the Challenger failure in January 1986. Only 3 SOAR reports were written in 1988. In January a disruption occurred in the MA (Multiple Access) return link which affected service. The cause was unknown but it was corrected by re-calibrating the system. In mid-March some erratic null transitions in the Solar Array Drive Assembly-2 which was probably caused by normal wear debris. Also in mid-March the power cautioned and alarmed numerous times. There was no impact to user services.

TDRS-3: As mentioned above this spacecraft was successfully launched on September 29. In the first month following launch there were 6 anomaly reports written, all of a fairly minor nature. None affected operations. One of the SOAR's documented the failure of the SA-2 boom to deploy, when commanded, shortly after launch. It deployed spontaneously 2.5 hours later. It is suspected that it hung up on something and deployed when perturbed by a thruster firing about the time that it finally deployed. Approximately a month after launch the temperature on one of the hydrazine thrusters dropped to within less than 3 degrees of the freezing point of hydrazine. The operation procedures were modified to turn on heaters to prevent freezing. On December 21st Receivers A and B experienced false locks at different times while attempting to acquire K-Band uplink , during S-Band to K-Band switches. The operational procedures were changed to prevent this in the future.

As the year ended this spacecraft was operating satisfactorily and meeting all its requirements.

Anomaly Data: Classification and Description

In the table of anomalies the following information is provided:

1. Index -- This is a chronological enumeration of the anomalies, beginning at launch. Numbers lower than the first number used in this report will be found in earlier reports of the series.

2. Date -- This is the date of the occurrence of the anomaly, and in parentheses the number of days since launch is given, counting launch day as one.

3. Subsystem -- For the purposes of this data base, the spacecraft is divided into 9 subsystems. These are:

    1. Attitude Control & Stabilization (ACS)
    2. Power
    3. Propulsion
    4. Structure
    5. Telemetry & Data Handling (TLM & DH)
    6. Thermal
    7. Timing, Control & Command (TC & C)
    8. Instrument (payload)
    9. Other (name to be entered)

4. Criticality -- This describes the impact of the anomaly on the mission, according to the following schedule:

1. Negligible	(0- 5% loss)
2. Non-negligible but small (Minor)	(5 - 33%)
3. 1/3 - 2/3 Mission Loss (Substantial)	(33 - 66%)
4. 2/3 to Nearly Total Loss (Major)	(66 - 95%)
5. Essentially Total Loss (Catastrophic)	(95 - 100%)

5. Description -- A brief description of the anomaly and its probable cause, if known.

6. Effect/Action -- The effect of the anomaly on the mission and corrective action, either for this mission or future missions, if any and if known.

7. Reference -- The number on the SCAR, TOAR, or GAR (if any) covering this particular incident.

Anomalies are also classified in various ways for the purpose of statistical analysis. SOAR calls for the following classifications:

ITEM	CODE	DESCRIPTION
Impact:	1	Spacecraft failed
	2	Subsystem/instrument failed
	3	Component failed
	4	Assembly failed
	5	Part failed
	6	Subsystem/instrument degraded
	7	Indeterminate
	8	Loss of redundancy
	9	None
Failure Category:	1	Design problem
	2	Workmanship problem
	3	Part problem.
	4	Environmental problem
	5	Other (w/explanation)
	6	Unknown
Type of Anomaly:	1	Systematic (would occur if identical equipment were operated under identical circumstances)
	2	Random
	3	Wear out (a special case of systematic)
	4	Indeterminate
	5	Intermittent

These classifications for the 1988 anomalies are given in Table I.

Using the data in Table I, the 25 “1988 anomalies" can be summarized as follows**:**

Type of Anomaly	No. of Anomalies
Systematic	5
Random	2
Wear out	3
Indeterminate	14
Intermittent	1

Criticality	No. of Anomalies
Negligible	22
Minor	3
1/3 to 2/3 Mission Loss	0
2/3 to Nearly Total Loss	0
Total Loss	0

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All 25 anomalies in 1988 were either Negligible or Minor in Criticality.

TABLE I

CLASSIFICATION OF 1988 ANOMALIES

Spacecraft	A	B	C	D	E	F	
AMPTE/CCE	10	2	1	3	6	4	
	11	7	2	3	5	1	
ERBS	11	1	2	4	5	3	
GOES-4	[41	5	2	3	3	4]	< 1987 Anomaly
GOES-6	[18	8	2	5	1	3]	< " "
	[19	8	1	9	4	4]	< " "
	[20	3	1	9	6	4]	< " "
	21	5	1	6	6	4	
GOES-7	[9	8	1	7	6	4]	< " "
	[10	8	1	9	6	4]	< " "
	11	5	1	9	4	4	
	12	5	1	9	1	1	
NIMBUS-7	53	5	1	9	6	4	
	54	7	1	9	6	4	
NOAA-9	31	8	1	9	6	4	
NOAA-10	11	8	1	6	5	3	
	12	2	1	9	5	4	
	13	8	2	2	6	4	
	14	5	1	7	6	4	
	15	8	1	6	6	4	
NOAA-11	1	8	1	6	6	4	
TDRS-1	52	8	1	7	6	2	
	53	2	1	7	5	3	
	54	8	1	9	6	4	
TDRS-3	1	5	1	9	5	5	
	2	4	1	9	6	4	
	3	3	1	7	5	1	
	4	3	1	9	1	1	
	5	1	1	7	6	4	
	6	3	1	7	1	1	
	7	7	1	7	6	2	

A	=	Index
B	=	Subsystem
C	=	Criticality (Mission Effect)
D	=	Impact
E	=	Failure Category
F	=	Type of Anomaly

INDEX	DATE/(DAYS)	SUBSYSTEM	CRITICALITY	DESCRIPTION	EFFECT/ACTION	REF.
				AMPTE/CCE		
10	1/30/88 (1262)	Power	1	Coulometer 2 on battery 1 & 2 failed. Coulometer 1 on battery 2 is still ok.	Negligible/ None	A01111
11	4/16/88 (1339)	TC&C	2	Command Processor #1 stopped receiving all S/C commands. CP #1 Failed.	Minor/Switch to CP #2.	A01110
				DE-1		
				NO ANOMALIES REPORTED IN 1988.		
				ERBS		
11	7/11/88 (1375)	ACS	2	Y-Gyro in IRU-2 stopped. Bearings failed.	Minor/Switch to IRU-1.	A01109
				GOES-4		
41	(11/6/87]* (2614)	TLM&DH	2	DCPR XMTR-2 failed - no output power. Unknown part failure	DCS Ops ended/ Switch to DCPR-1	115
				GOES-5		
				NO ANOMALIES REPORTED IN 1988.		
				GOES-6		
18	[10/5/87]* (1621)	INST-VAS	2	Redundant Scan Drive Encoder Lamp 1 failed.	Minor/Last encoder lamp selected.	113
19	[11/1/87]* (1648)	INST-VAS	1	Transient event shifted VAS Earth-view window and put x-ray in CAL mode. Probably electrostatic discharge.	Negligible/None	114

INDEX	DATE/(DAYS)	SUBSYSTEM	CRITICALITY	DESCRIPTION	EFFECT/ACTION	REF.
20	[12/15/871* (1692)	PROPULSION	1	E-W maneuver produced only 27% of predicted orbit change.	Negligible/ Correct data in GMACS.	116
21	3/9/88 (1777)	TLM&DH	1	RTU-1-8 Analog; 4 bilevel RTU-2-2 analog; 1 bilevel channels failed.	Negligible/	117
				GOES-7		
9	[7/16/87]* (140)	INST-VAS	1	PMT-5 gain circuitry malfunction. Probably failed component or PWB in gain-step circuitry.	Minor/Can be handled be ground.	111
*10	[9/14/871* (200)	INST-VAS	1	VAS channel 5 uncommanded gain step. "Phantom" command.	Negligible/ Reset by ground Cmd.	112
11	6/10/88 (470)	TLM&DH	1	CTU-1 switch from REPLY BUS A to B. First GOES-7 SEU.	Negligible/Corr. by ground Cmd.	118
12	9/16/88 (568)	TLM&DH	1	Ranging xponder 1 & 2 low output power when cold post-eclipse.	Negligible/Delay ranging.	119

ICE

NO ANOMALIES REPORTED IN 1988.

IUE

NO ANOMALIES REPORTED IN 1988.

LANDSAT-4

NO ANOMALIES REPORTED IN 1988.

LANDSAT-5

NO ANOMALIES REPORTED IN 1988.

INDEX	DATE/(DAYS)	SUBSYSTEM	CRITICALITY	DESCRIPTION	EFFECT/ACTION	REF.
				NIMBUS-7		
53	6/2/88 (3509)	TLM&DH	1	Tape recorder #3 had noisy area on tape - 10 min. unusable data- happened again in different area.	Minor/After re-record ok	A01201
54	7/28/88 (3565)	TC&C	1	The command from Cmd. Mem., xponder xmtr. "off", did not execute. Cause unknown.	Minor/None	A01202
				NOAA-9		
31	6/11/88 (1277)	INST-HIRS	1	HIRS filter motor current decreased by 10 ma with associated one-time sync loss. Instrument data normal.	Negligible/ None	274
			1	**NOAA-10**		
11	4/21/88 (582)	INST-AVHRR	1	Channel 3 noise, sync delta, and motor current all abruptly increased. Lack of lube in motor bearings suspected.	Negligible/ None	272
12	5/13/88 (604)	POWER	1	Voltage spikes of about -6v. seen on partial shunt voltage bus.	Negligible/ Offset arrays.	273
13	9/9/88 (723)	INST-SARP	2	SARP failed – ceased transmitting. No redundant xmtr.	Minor/None possible.	276
14	9/17/88 (731)	TLM&DH	1	HRPT reception experiences 25db dip in signal strength. Seen before on previous missions. Some data loss.	Negligible/ None	275
15	12/4/88 (809)	INST-AVHRR	1	Motor current erratic – many dropouts; data unusable in this (1 hr.) period. Temperature dependent.	Negligible/ None	278

INDEX	DATE/(DAYS)	SUBSYSTEM	CRITICALITY	DESCRIPTION	EFFECT/ACTION	REF.
				NOAA-11		
1	10/6/88 (12)	INST-SARR	1	Side A experimental 406.5 Mhz receiver. Channel has 2OdB loss in sensitivity from design value.	Negligible/ Canada investigating.	277
				SMM		
				NO ANOMALIES REPORTED IN 1988.		
				TDRS-1		
52	1/21/88 (1753)	INST-MA	1	Disruption occurred in MA return link, affecting service. Cause unknown. Corrected by re-calibrating system.	Minor/Operating instructions modified.	A01227 (71)
53	3/17/88 (1809)	POWER	1	Experienced erratic null transitions in Solar Array Drive Assembly-2. Probably caused by normal wear debris.	Negligible/ None required.	A01228 (72)
54	3/18/88 (1810)	INST-SSA	1	Power has cautioned & alarmed numerous times. No impact to user services.	Negligible/ None needed.	A01229 (73)
				TDRS-3		
1	9/30/88 (2)	TLM&DH	1	A TLM parameter cautioned at 0.3V in KG-A Encryp. Unit. No problem to ops.	Negligible/ Contingency plan in place.	A01232 (74)
2	9/30/88 (2)	STRUCTURAL	1	SA-2 Boom did not deploy when commanded- deployed spontaneously 2.5 hours later. Hangup suspected.	Negligible/ None required.	A01233 (75)
3	10/3/88 (5)	PROPULSION	1	During first Delta-V, anomalous attitude occurred due to closed Isovalve-AA. Cycling corrected it.	Negligible/ Launch proced. modified.	A01234 (76)

INDEX	DATE/(DAYS)	SUBSYSTEM	CRITICALITY	DESCRIPTION	EFFECT/ACTION	REF.
4	10/3/88 (5)	PROPULSION	1	Isovalue-AA telemetry indicated "open" when "closed". Cycling corrected problem.	Negligible/ Ops. Procedures noted.	A01235 (77)
5	10/25/88 (27)	ACS	1	CPE spontaneously re-initialized due to transient of unknown origin.	Minor/RAM. re-configured.	A01236 (78)
6	10/25/88 (27)	PROPULSION	1	Thruster + RlB temp. was 37.3 Deg F. and hydrazine freezes at 34.7 Deg F.	Negligible/ ops. Procedure changed to turn on heater.	A01237 (79)
7	12/21/88 (83)	TC&C	1	Receiver A & B false locked separately while attempting to acquire K-Band uplink during S-Band to K-Band switches.	Negligible/ Changed ops. proced. to prevent.	A01238 (80)

*Not received until 1988.

APPENDIX A

SPACECRAFT LIFETIME DATA

NOTE: In the following table, the term “useful life” refers to the time during which the major mission objectives were met. Active life is the total lifetime during which the satellite remained in service. A blank space means the information was not available. Data is through 1988; see text for update.

SPACECRAFT LIFETIMES

SPACECRAFT	LAUNCH DATE	DESIGN LIFE (YRS)	USEFUL LIFE (YRS)	ACTIVE LIFE (YRS)	REMARKS
TIROS	4/1/60	0.25	.24	.24	TV system useful for 77 days
Explorer VIII (S-30)	11/3/60	0.25	.15	.15	Last transmission 12/28/60
TIROS-II	11/23/60		.63	1.03	TV data useful to 7/12/61
Explorer XI (S-15)	4/27/61		.61	.61	Last transmission 12/7/61
TIROS-III	7/12/61	.25	.40	.63	TV data useful to 12/4/61. Lost tape recorders.
Explorer XII (S-3)	8/15/61	1.0	.31	.31	Transmission ceased abruptly
TIROS-IV	2/8/62	0.25	.36	.44	TV useful to 6/9/62. Lost tape recorders.
OSO-I	3/7/62	0.5	1.40	1.40	Lost tape recorder @ 2 mos. starfish incident degraded power system.
Ariel-I (S-51)	4/26/62	1.0	0.88		Degraded by starfish incident of 7/9/62.
TIROS-V	6/19/62	0.5	0.88	0.88	TV useful to 5/4/63. Camera filaments failed.
TIROS-VI	9/18/62	0.5	1.06	1.06	TV useful to 10/11/63. Filaments and focus out.
Explorer XIV (S-3a)	10/2/62		0.85	1.20	Last transmission 2/17/64
Explorer XV (S-3b)	10/27/62	0.17	0.26	0.55	Despin system failed. Last transmission 5/19/63.
Relay I	12/13/62	2.0	2.53	2.53	
Syncom I	2/14/63	2.0	0	0	Lost power, mission failure.
Explorer XVII (S-6)	4/3/63	0.25	.27	.27	Batteries degraded. No solar array.
TIROS-VII	6/19/63	0.5	4.33	4.96	Deactivated. Camera focus out 12/65.
Syncom II	7/26/63	2.0	N/A	N/A	
IMP-A	11/26/63	1.0	0.82		
TIROS-VIII	12/21/63	0.5	3.53	3.53	Deactivated.
Relay-II	1/21/64	1.0	1.68	3.50	
Ariel-II (S-52)	3/27/64	1.0	0.53		Had spin rate and attitude control problems.
Syncom III	8/19/64	3.0	N/A	N/A	
Explorer XX (S-48)	8/25/64		1.60	1.60	Based on last transmission 3/30/66.
Nimbus-I	8/28/64	0.5	0.07	0.07	Solar array drive failed.
OGO-1(A)	9/4/64	1.0	5.23	5.23	Mission failure. 3-axis stabilization not achieved.
IMP-B	10/3/64	1.0	0.50	1.25	Reentered. Placed in wrong orbit.
Explorer XXVI (S-3c)	12/21/64	1.0	2.10	2.10	Last transmission 1/21/67.
TIROS-IX	1/22/65	0.5	2.73	3.4	Deactivated. Camera contrast out 10/66.

SPACECRAFT LIFETIMES

SPACECRAFT	LAUNCH DATE	DESIGN LIFE (YRS)	USEFUL LIFE (YRS)	ACTIVE LIFE (YRS)	REMARKS
OSO-II	2/3/65	0.5	0.75	0.75	Used up control gas.
IMP-1(C)	5/29/65	1.0	1.92	1.92	Reentered.
TIROS-X	7/2/65	1.0	1.16	2.00	Deactivated.
OGO-2(C)	10/14/65	1.0	3.48		Mission failure: Horizon scanners did not maintain earth lock.
ESSA-I	2/3/66	1.0	2.36	2.36	Deactivated.
ESSA-II	2/28/66	1.0	4.64	4.64	Deactivated.
OAO-I	4/8/66	1.0	0	0	Mission failure: Lost power
Nimbus-II	5/16/66	0.5	2.67	2.67	ACS scanner failed.
AE-B	5/25/66	0.5	0.82		Higher than planned orbit. Two sensors did not work.
OGO-3(B)	6/6/66	1.0	2.04	3.5	Boom oscillation problem.
AIMP-2(D)	7/1/66	0.5	4.92		Failed to achieve lunar orbit.
ESSA-III	10/2/66	1.0	2.02	2.02	Deactivated. Cameras failed
ATS-I	12/6/66	3.0		ACTIVE	Gas expended. Limited service
ESSA-IV	1/26/67	1.0	0.41	1.27	Deactivated. One camera failed, one degraded.
OSO-III	3/8/67	0.5	3.0	3.0	Tape recorder failure at 18 mos. ACS controlled manually.
ESSA-V	4/20/67	1.0	2.83	2.83	Deactivated. IR failed, cameras gradually degraded.
IMP-3(F)	5/24/67	1.0	1.95	1.95	Reentered.
AIMP-4(E)	7/19/67		3.50	3.50	Lunar orbit. Subsequent period of intermittent operation.
OGO-4(D)	7/28/67	1.0	2.24	2.75	Thermal bending of antenna caused stabilization control problem.
OSO-IV	10/18/67	0.5	0.90		Tape recorder failure at 6 mos.
ATS-III	11/5/67	3.0		ACTIVE	Instruments no longer in use
ESSA-VI	11/10/67	1.0	2.09	2.09	Deactivated Cameras degraded
OGO-5(E)	3/4/68	1.0	3.60	3.60	Deactivated. Data glut
RAE-A	7/4/68	1.0	4.50	4.50	Deactivated. Data quality had become marginal.
ESSA-VII	8/16/68	1.0	0.92	1.56	Deactivated. Early camera and tape recorder failures
OAO-II	12/7/68	1.0	4.20	4.20	Prime instrument (WEP) failed.
ESSA-VIII	12/15/68	1.0	4.95	6.75	Deactivated. Camera problems
OSO-V	1/22/69	0.5	3.9	3.9	

SPACECRAFT LIFETIMES

SPACECRAFT	LAUNCH DATE	DESIGN LIFE (YRS)	USEFUL LIFE (YRS)	ACTIVE LIFE (YRS)	REMARKS
ESSA-IX	2/26/69		4.1	4.1	Deactivated. Standby after 4/71.
Nimbus-3	4/19/69	0.5	2.67		ACS Scanner failed 1/72.
OGO-6 (F)	6/5/69	1.0	2.06	2.25	Deactivated. Data glut
IMP-5(G)	6/21/69		3.51	3.51	Reentered.
OSO-VI	8/9/69	0.5	3.30	3.30	
ATS V	8/12/69	3.0	14.84	14.84	Mission officially unsuccessful: Stabilization not achieved. Deorbited 3/20/84
TIROS-M	1/23/70	1.0	1.40	1.40	Momentum wheel assembly failed.
Nimbus-4	4/8/70	1.0	10.00	10.00	Deactivated.
NOAA-1 (ITOS-A)	12/11/70	1.0	.56	0.75	Deactivated. Momentum wheel assembly problems.
SAS-A	12/12/70	0.5	4.00	4.00	Transmitter failure terminated mission.
IMP-6(I)	3/13/71	1.0	3.56	3.56	Reentered.
OSO-VII	9/29/71	0.5	3.17	3.17	Reentered due to bad orbit
SSS-A	11/15/71	1.0	2.87	2.87	Deactivated. Battery unusable, as expected after 1 year.
Landsat-1 (ERTS-A)	7/23/72	1.0	5.58	5.58	Deactivated: Funding withdrawn
OAO-C	8/21/72	1.0	8.50	8.50	Deactivated: Funding withdrawn
IMP-7(H)	9/22/72	2.0	6.10	6.10	Power system failed.
NOAA-2 (ITOS-D)	10/15/72	1.0	2.25	2.40	Standby after 3/74. Some experiments failed.
SAS-B	11/16/72	0.5	.54	.54	Experiment low voltage power supply failed.
Nimbus-5	12/12/72	1.0	10.30	10.30	Deactivated 3/31/83. Second HDRSS failed 7/27/82.
RAE-B	6/10/73	1.0	3.75	3.75	Deactivated. Mission objectives achieved.
IMP-8(J)	10/25/73	2.0	ACTIVE	ACTIVE	All instruments operating.
NOAA-3 (ITOS-F)	11/6/73	1.0	2.84	2.84	Deactivated. Radiometer, VTPR, VHRR out
AE-C	12/16/73	1.0	5.00	5.00	Reentered.
SMS-1	5/17/74	2.0	1.60	6.70	Standby after 1/76. Deactivated 1/31/81.
ATS-6(F)	5/30/74	5.0	5.17	5.17	Deactivated.
NOAA-4 (ITOS-G)	11/15/74	1.0	4.00	4.00	Deactivated. Radiometer, VHRR's out.
Landsat-2	1/22/75	1.0	8.51	8.51	Yaw flywheel stopped 11/79, recovered 5/80. Permanently turned off July 27, 1983.
SMS-2(B)	2/6/75	2.0	6.50	7.50	Second encoder failed on 8/5/81.

SPACECRAFT LIFETIMES

SPACECRAFT	LAUNCH DATE	DESIGN LIFE (YRS)	USEFUL LIFE (YRS)	ACTIVE LIFE (YRS)	REMARKS
SAS-C	5/7/75	1.0	4.92	4.92	Reentered.
Nimbus-6(F)	6/12/75	1.0	7.18	8.28	Yaw flywheel failed 8/14/82.
OSO-8(I)	6/21/75	1.0	3.40	3.40	Funding withdrawn
AE-D	10/6/75	1.0	0.42	0.42	Shorted diode in power supply electronics.
GOES-1(A)	10/16/75	3.0	9.3	9.4	VISSR failed 2/85
AE-E	11/20/75	1.0	5.56	5.56	Reentered 6/10/81
NOAA-5 (ITOS-H)	7/29/76	1.0	2.96	2.96	Failed 7/79
GOES-2 (B)	6/16/77	3.0	1.55	1.55	VISSR failed 1/79
ISEE-1(A)	10/22/77	2.0	9.93	9.93	S/C re-entered 9/26/87
IUE	1/26/78	3.0	ACTIVE	ACTIVE	Fully operational. Some problems w/ computer "HALTS"
Landsat-3(C)	3/5/78	3.0	5.07	5.51	Problems with MSS instrument
AEM-A (HCMM)	4/26/78	1.0	2.40	2.40	Deactivated. Battery degraded 9/14/80.
GOES-3(C)	6/16/78	3.0	2.21	7.89	VISSR degraded 9/80. Failed 5/6/81. S/C to standby 4/28/86.
ISEE-3(C) [ICE]	8/12/78	2.0	ACTIVE	ACTIVE	Some instrument losses.
TIROS-N	10/13/78	2.0	2.38	2.38	ACS failed 2/27/81.
Nimbus-7(G)	10/24/78	1.0	ACTIVE	ACTIVE	Solar array power and some instruments degraded.
AEM-B (SAGE)	2/18/79	1.0	2.75	2.75	Battery degraded. Failed 11/18/81.
NOAA-6(A)	6/27/79	2.0	7.39	7.75	S/C turned off 3/31/87
Magsat	10/30/79	0.4	.61	.61	Reentered as planned 6/11/80
SMM*	2/14/80	2.0	[0.83] +[5.62]	ACTIVE	Lost fine pointing control 12/12/80, then repaired.
GOES-4(D)	9/9/80	7.0	2.21	6.66	VAS failed 11/25/82.
GOES-5(E)	5/22/81	7.0	3.19	ACTIVE	VAS failed 7/30/84.
NOAA-7(C)	6/23/81	2.0	3.62	4.92	Failed HIRS, degraded SSU, disabled power system.
DE-1(A)	8/3/81	1.0	ACTIVE	ACTIVE	
DE-2(B)	8/3/81	1.0	1.54	1.54	Reentered as expected 2/19/83.
OSS-1	3/22/82	--	--	--	Shuttle attached payload mission.
Landsat-4(D)	7/16/82	3.0	ACTIVE	ACTIVE	Partial solar array loss.
NOAA-8(E)	3/28/83	2.0	1.25	1.25	Failed 7/1/84. Recovered May 1985. Failed again 1/86.

SPACECRAFT LIFETIMES

SPACECRAFT	LAUNCH DATE	DESIGN LIFE (YRS)	USEFUL LIFE (YRS)	ACTIVE LIFE (YRS)	REMARKS
TDRS-1(A)	4/4/83	**	ACTIVE	ACTIVE	Some loss of capability.
GOES-6(F)	4/28/83	7.0	ACTIVE	ACTIVE	Using last good encoder lamp.
Landsat-5(D')	3/1/84	3.0	ACTIVE	ACTIVE	K-Band failed; can't send TM data via TDRS-1 (Late '87)
AMPTE/CCE	8/16/84	1.0	ACTIVE	ACTIVE	Some solar array degradation.
ERBS	10/5/84	2.0	ACTIVE	ACTIVE	IRU-1/X-gyro failed (8/86), IRU-2/Y-gyro failed (7/88).
NOAA-9(F)	12/12/84	2.0	3.92	ACTIVE	MSU & ERBE-S failure. Placed in standby 11/8/88.
SPARTAN-1	6/20/85	--	--	--	STS attached payload mission
SPOC/HITCHHIKER	1/12/86	--	--	--	STS attached payload mission
NOAA-10(G)	9/17/86	2.0	ACTIVE	ACTIVE	Array shunts degraded & SARP failed 9/9/88.
GOES-7(H)	2/26/87	7.0	ACTIVE	ACTIVE	
NOAA-11(H)	9/24/88	2.0	ACTIVE	ACTIVE	Y-gyro & DTR 5 A & B failed in late 1989.
TDRS-3(C)	9/29/88	**	ACTIVE	ACTIVE	

* Repaired by crew of shuttle flight 41-C on April 12, 1984.
** Complex warranty provisions call essentially for 10-year service from TDRSS system.